

Circle and “J” Hook Pilot Study in Maryland’s Recreational Shark Fishery

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Introduction

Although circle hooks have been around for a long time, their use as a conservation measure did not start gaining momentum until the late 1990’s (Straughn, Unknown). Since that time, voluntary and mandatory usage of circle hooks has rapidly expanded into many fisheries. There are numerous studies of recreational use of circle hooks in teleost fisheries as well as commercial studies on sharks from the Pelagic Long Line fishery (PLL; Serafy et al., 2011; Lucy et al., 2002; Cook and Suski, 2004; Diaz, 2008; Watson et al., 2005; Skomal et al., 2002; Kaplan et al., 2007; Graves and Horodysky, 2008). The weight of evidence suggests that fewer fish are deep hooked and catch efficiency is equal to or better than J hooks. This research has helped circle hooks gain acceptance and supported regulatory requirements for their use in some fisheries and tournaments (Cook and Suski 2004; Straughn, Unknown; Graves and Horodysky, 2008).

Some anglers have been reluctant to switch to circle hooks because of catch efficiency concerns and doubts about study results’ applicability in the shark fishery (Prince et al., 2002). Previous conclusions from teleost recreational studies may not apply to sharks due to differences in anatomy and behavior (Cook and Suski, 2004; Serafy et al., 2011; Lucifora et al., 2009; Hammerschlag et al., 2011). Furthermore, results from PLL studies may not translate well into the recreational fishery due to differences in methodology such as gear and bait. Despite the abundance of circle hook studies in teleost fisheries and commercial shark fisheries, there are no published studies and only one symposium poster presentation for circle hooks in the recreational shark fishery (Hammerschlag et al., 2011). Scientific evidence supporting the benefits of circle hooks is needed to convince recreational shark anglers to voluntarily switch hook types and to support regulatory measures requiring circle hook use (Prince et al., 2002; Skomal et al., 2002; Graves and Horodysky, 2008).

The recreational shark fishery has a large release component resulting from angler preference, regulations, and tournament rules. In Maryland, sharks are targeted by tournament and non-tournament anglers from May into October. In addition to tournament favorites such as Mako (*Isurus oxyrinchus*), Thresher (*Alopias vulpinus*), and Blue (*Prionace glauca*) sharks there are three prohibited species that are commonly caught: Sandbar (*Carcharhinus plumbeus*), Dusky (*Carcharhinus obscurus*), and Sand Tiger (*Carcharias taurus*) sharks. The federal HMS 2012 Recreational Compliance Guide requires prohibited species to be released in a manner that maximizes the probability of survival, without removing the fish from the water. The Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fishery Management Plan for Atlantic Coastal Sharks (2008) includes the goal to promote complementary management in state and federal waters.

If circle hooks reduce deep hooking in the recreational shark fishery, they could benefit shark populations by lowering catch-and-release fishing mortality. If circle hooks lower catch-and-release fishing mortality in sharks, then it would be beneficial to expand their use in the recreational shark fishery. The potential benefits of circle hooks to sharks notwithstanding, most

recreational shark anglers will only be persuaded to switch tackle if they can first be persuaded that circle hooks maintain or improve catch efficiency.

The goal of this pilot study was to obtain evidence concerning the differential hooking effectiveness and catch efficiency of circle hooks and traditional J hooks in Maryland's recreational nearshore and offshore fisheries. Specifically, this study was designed to answer the following three questions:

1. Is catch rate different between hook types?
2. Is the hooking outcome (landed versus lost) different between hook types?
3. Is the frequency of deep hooking different between hook types?

Methods

Field Methods

A pilot study was conducted to determine how many catches were needed to perform these analyses. The sample size needed to determine statistical significance was dependent on the ability to minimize changes in methodology such as bait type, bait species, tackle, and presentation (Diaz 2008). Other variables (such as species composition, weather, and water temperature) were uncontrollable factors that may also influence sample size.

The study area was stratified into nearshore and offshore zones because of differences in species composition and tackle requirements. For purposes of this study, nearshore was defined as waters from the beach to 20 miles and offshore was defined as waters 20 or more miles from the beach. Most of the nearshore fishing occurred from one to six miles from the beach and the majority of offshore fishing took place between 20 and 30 miles from the beach. All fishing trips left from Ocean City, Maryland.

Consistent fishing practices were preferred. Minimizing variables (baits, gear, and depth) introduced into the study minimizes the sample size needed to determine if there are significant statistical differences. Captain Mark Sampson chartered and fished as he normally did with the exception of dedicating two surface lines to this study while on dedicated shark trips.

Fishing was conducted from either a drifting or anchored boat. Changes to fishing mode or location during a charter were indicated on the datasheet under 'Notes' and in the corresponding 'Condition and Comments' field.

Chum was used to attract sharks to the area. Baited lines attached to conventional sport fishing rods and reels were used to hook and land the sharks. Study lines were attached to floats and fished at the surface (< 2 m). The captain or mate attempted to set the hook when using a J hook and the rod was left alone for self hooking when circle hooks were used. However, if a shark continued to swim towards the boat after taking a bait, the rod was left in the rod holder and the reel was cranked to tighten the line and allowed the hook to set. Once the shark was hooked on either hook, the angler then took the rod from the rod holder.

Study lines were identical to each other and were rigged either with circle hooks or a comparably sized J hook. Both hooks were switched to the other type of hook after every bite.

Circle hooks were limited to Mustad model 39960D hooks in sizes 16/0 and 13/0 (Mustad 2011). The 16/0 hooks were used when fishing offshore where larger sharks were anticipated and larger baits are typical. When fishing nearshore and using smaller baits for smaller sharks 13/0 circle hooks were used.

J hooks were limited to Mustad model 7731D hooks in sizes 9/0 and 6/0. The 9/0 J hooks were used when fishing offshore where larger sharks were anticipated and larger baits are typical. When fishing nearshore and using smaller baits for smaller sharks 6/0 J hooks were used.

Bait type was allowed to change daily as needed; however it was required to be identical in size and species on both lines at the same time. Baits were refreshed at the same time. The species of the bait and whether or not it was frozen or fresh were recorded on the datasheet.

The outcome of each shark strike was recorded as bite, lost, or landed similar to Skomal et al. (2002; Figure 1). A fish bite was defined as a strike that results in the fish not being hooked. The captain or mate would make the determination either by looking over the remaining bait for teeth marks or by visually observing the shark. The event was not recorded if the captain or mate could not confirm that it was a shark bite. Lost was defined as a hooked fish that became unhooked before the mate could grab the leader. Landed was indicated on the datasheet when the shark was fully played to the boat. Fight time was recorded in minutes and began when the angler grabbed the rod and ended when the mate had the leader at the side of the boat.

The captain or mate completed the datasheet only for sharks that interacted with the study lines. Once the shark was landed, the captain determined if it was to be boated or kept in the water next to the boat for workup. Species, hook type, size, location, and length were recorded on the datasheet. Hook location was recorded as jaw, visible in throat, gut, and foul. Hooks were removed using a dehooker or had the line cut; the captain or mate selected the appropriate method that provided the shark the maximum likelihood of survival. Boated sharks were measured for total and fork lengths in inches using a fiberglass measuring mat placed on the floor. Lengths were estimated for sharks that were not boated. Estimated weight and sex were determined for most landed sharks. Additional variables on the datasheet included fields for location, latitude, longitude, start and end times, boat (anchored or drifting), and condition/comments. Datasheets were periodically collected for data entry by MDNR.

Statistical methods

Data from the pilot study were used to determine appropriate sample size. The empirical distributions of hooking outcome and hook type were determined to compose “expected” percent frequency distributions. Using the minimum acceptable frequency of five observations in each cell (according to chi square test theory), these percentage distributions were expanded to absolute frequency distributions. The sum of frequencies in all cells was the minimum sample size needed to support chi square analysis.

To answer whether catch rate was different between hook types in the midst of numerous other factors, a Generalized Linear Mixed Model (GLMM) analysis was applied to estimate the mean catch rate for each hook type and determine the effect of hook type (Prince et al., 2002). A chi square test of independence was conducted on hooking outcome data to determine whether

hooking outcome was independent of hook type (Skomal et al., 2002). The same test was performed to answer whether hooking location was independent of hook type (Skomal et al., 2002).

Results

Captain Sampson provided study data from 87 charter trips targeting sharks both offshore (14 trips) and nearshore (73 trips). A chi square test indicated that the offshore and nearshore data were not statistically different and therefore it was appropriate to pool those data ($p=0.401$).

Ten shark species were captured in the study (Table 1). Dusky Sharks (102 sharks), Spinner Sharks (99 sharks), and Sandbar Sharks (37 sharks) were the most commonly encountered species in the study. Captain Sampson recorded a total of 365 interactions with the study rods (Table 2, Figure 2). Most interactions were landed (305) although there were 39 bites and 21 losses. Out of the 305 landed sharks, more were caught using circle hooks (181 sharks) than on J hooks (124 sharks). The GLMM analysis indicated the mean CPUE (sharks landed/hook type/trip) was 2.25 and 1.69 for J hook. Additionally, it confirmed that the catch rate was different between hook types ($p=0.0038$). A chi square test indicated that the hooking outcome between hook types was significant ($p=0.0006$).

Most landed sharks were hooked in the jaw (264 sharks; Table 3). Results from the chi square test indicated that there was a significant difference in the frequency of deep hooking between hook types ($p=0.001$). However, it should be noted that three out of eight cells had four observations and one was five which means that 50% of the cells were at or under the minimum acceptable frequency of five observations per cell for chi square theory.

A minimum of 230 circle hook caught sharks and 125 J hook sharks were needed to determine if a significant difference exists for hooking locations (Table 4). The chi square test to determine significance for deep hooking by hook type lacked enough observations to meet chi square theory (minimum of 5 observations per cell) for 50% of cells; therefore, the data were examined to determine an appropriate sample size (Table 5). This analysis indicated that an additional 50 sharks are needed to provide the minimum sample size for future work.

Discussion

Coastal sharks (Dusky, Spinner, Sandbar, Atlantic Sharpnose, Blacktip Sharks, Scalloped Hammerhead, and Tiger Sharks) were encountered more in this study than pelagic sharks (Shortfin Mako, Blue, and Thresher Sharks) because there were more nearshore than offshore trips. The offshore sample size may have been affected by the short offshore shark season which typically lasts from early May to the end of June. June 2012 had several bad weather days that prevented offshore fishing. Additionally, due to the distance traveled to get offshore there was also no chance of multiple trips per day which is possible when fishing nearshore.

Circle hooks outperformed J hooks in hooking (catch rate) and landing sharks (hooking outcome). There were fewer bites without landings reported on circle hooks and a higher proportion of landed sharks whereas there were more J hook bites but fewer landed sharks

(Figures 1 - 2). The lower proportion of sharks lost on circle hooks may be a result of the difference in setting technique used for the hook type and hook design (Prince et al., 2002; Cook and Suski, 2004). With circle hooks the shark hooks itself rather than the angler setting the hook as with J hooks.

Overall few sharks were deep hooked in this study and circle hook landings had fewer occurrences of deep hooking than J hooks. Preliminary data indicate that there may be a significant difference in deep hooking between the hook types. More data are needed to improve the statistical power.

Minimizing shark release mortality is important to the stock recovery for several prohibited shark species including Dusky Sharks and Sandbar Sharks. Additionally, it could also improve the populations of sharks that are not prohibited and are often released because they are undersized or undesirable. Results from the pilot year of this study indicate usage of circle hooks for sharking could improve adherence to the federal HMS Recreational Compliance Guide (2012) that requires prohibited species to be released in a manner that maximizes the probability of survival.

Recommendations

- Continue this survey for 2013 utilizing the same basic methodology. Captain Sampson could add one additional rod or take more trips to attain the desired increase in sample size.
- Perform a chi square test to confirm that data from 2012 and 2013 can be grouped for statistical analysis since shark behavior is not expected to change annually.

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Table 1. Species list of landed sharks captured during the 2012 Circle and J Hook Pilot Hook Study, n=305. Species are listed by total number landed.

Common Name (Scientific Name)	Total
Dusky Shark (<i>Carcharhinus obscurus</i>)	102
Spinner Shark (<i>Carcharhinus brevipinna</i>)	99
Sandbar Shark (<i>Carcharhinus plumbeus</i>)	37
Atlantic Sharpnose (<i>Rhizoprionodon terraenovae</i>)	30
Blue Shark (<i>Prionace glauca</i>)	14
Shortfin Mako Shark (<i>Isurus oxyrinchus</i>)	7
Blacktip Shark (<i>Carcharhinus limbatus</i>)	6
Hammerhead Shark, Scalloped (<i>Sphyrna lewini</i>)	5
Tiger Shark (<i>Galeocerdo cuvier</i>)	3
Hammerhead Shark, Smooth (<i>Sphyrna zygaena</i>)	2
Total	305

Table 2. Circle and J Hook Pilot Study hook type status interactions, n=365.

Hook Type	Status			Total
	Bite	Land	Lost	
Circle Hook	13	181	9	203
J Hook	25	124	12	161
Not Recorded	1			1
Total	39	305	21	365

Table 3. Circle and J Hook Pilot Study hook location by hook type, n=304. Note that one circle hook landing was excluded because it was considered entangled in the fishing line rather than being actually hooked.

Hook Type	Hook Location				Total
	Foul	Jaw	Throat	Gut	
Circle Hook	4	167	4	4	179
J Hook	5	97	13	10	125
Grand Total	9	264	17	14	304

Table 4. Desired number of landed sharks by hook type for the 2013 Circle and J Hook Study.

Hook Type	Minimum (2.2%)	Conservative (2.0%)
Circle Hook	227	250
J Hook	125	150
Grand Total	352	400

Table 5. Circle and J Hook Pilot Study chi square theory hook location additional percentage needed for landings by hook type.

Hook Type	Hook Location				Total
	Foul	Jaw	Throat	Gut	
Circle Hook	2.2%	93.3%	2.2%	2.2%	100%
J Hook	4.0%	77.6%	10.4%	8.0%	100%

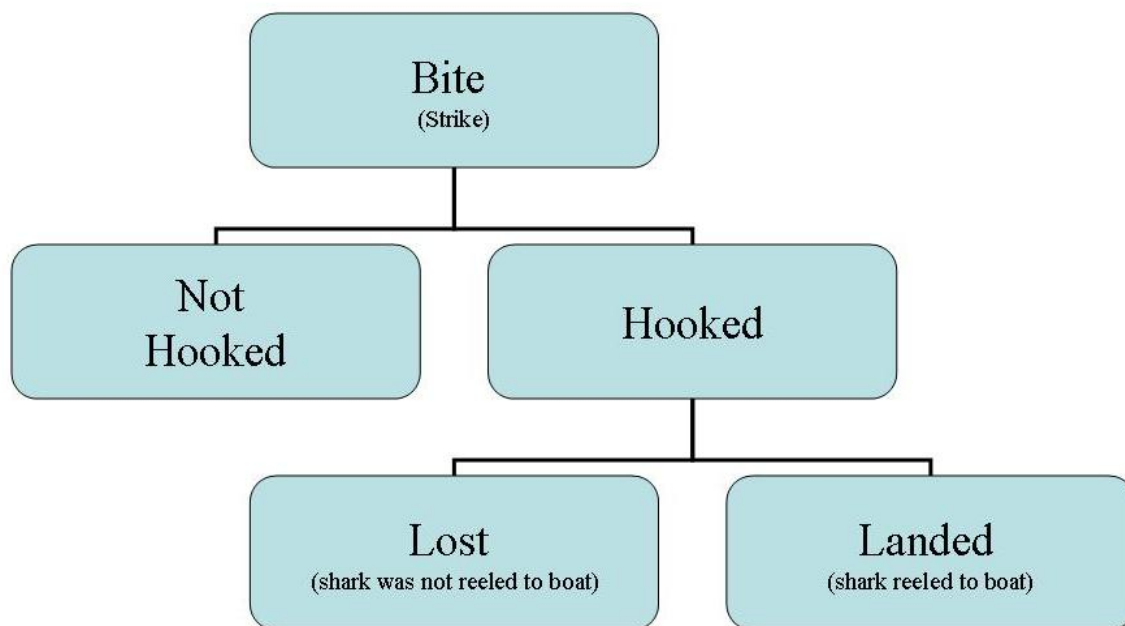


Figure 1. Strike outcome flow chart.

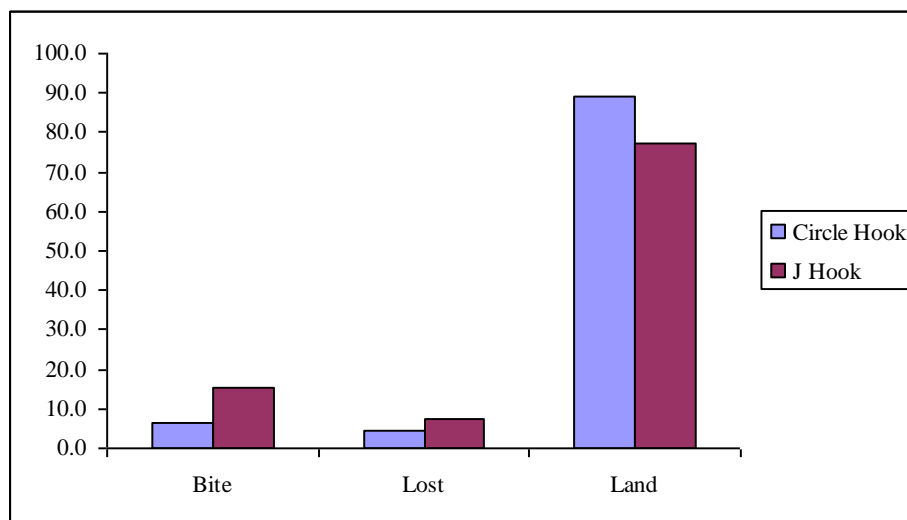


Figure 2. Percentage of bites, losses, and landed sharks by hook type, n=364. Note that hook type was not recorded for one bite; therefore, it is not included in this figure.